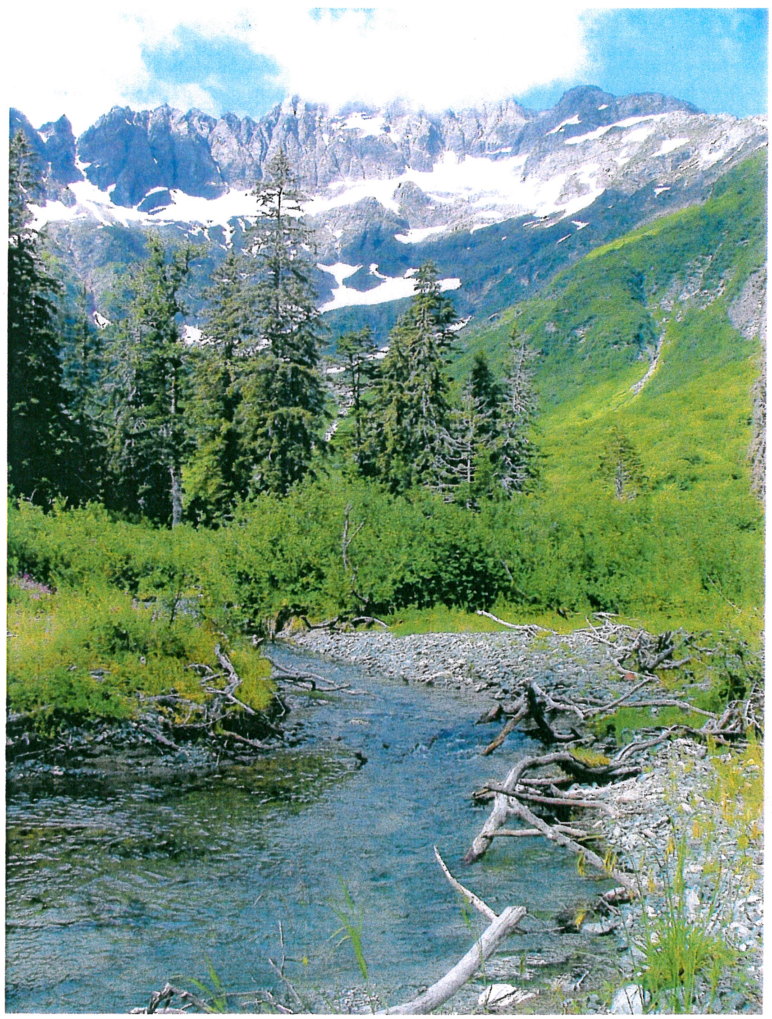
Kensington Gold Project

NPDES Permit AK-005057-1

Annual Water Quality Monitoring Summary
Volume 1:
Aquatic Resource Surveys
2005



March 2006

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1.0 Introduction

This volume of the annual report describes aquatic resource monitoring conducted in 2005 in compliance with the annual monitoring requirements of the National Pollutant Discharge Elimination System Permit for the Kensington Gold Project, near Juneau, Alaska (Permit No. AK-005057-1). Monitoring conducted on Sherman, Johnson and Slate Creeks included resident fish population estimates, anadromous spawning salmon estimates, quality of salmon spawning gravel, metal concentration and toxicity testing of stream sediment and aquatic vegetation surveys. Benthic invertebrate surveys were conducted on Johnson and Slate Creek as baseline data already exists for Sherman Creek invertebrates (Konopacky 1996).

2.0 Study Area

Sherman Creek drains an area of 10.59km^2 (4.09 mile^2) that ranges from 0 to 1,693m (5,552ft) in elevation (Konopacky 1992). It consists of four upper tributaries, Ivanhoe, Ophir, Upper Sherman and South Fork Sherman, which converge into a single channel approximately 1,500m from the stream mouth on the east shore of Lynn Canal (Figure 1). A permanent barrier to fish migration in the form of vertical falls exists 360m from the stream mouth. The only discharge to Sherman Creek from the Kensington Project is outflow from settling ponds that receive mine drainage (Figure 1).

Slate Creek and Johnson Creek drain into the north side of Berners Bay (Figure 1). Slate Creek drains an area of 11.61km^2 (4.48 mile^2) and has vertical fall barriers that prohibit fish passage on both East and West forks approximately 800m from the stream mouth. Johnson Creek drains an area of 19.97km^2 (7.71 mile^2) and has impassable barrier falls approximately 1,200m upstream from the confluence with Berners Bay. A tunnel connecting the existing Kensington Mine with Berners Bay is proposed within the Johnson Creek drainage, while the Tailings Storage Facility is proposed to be at Lower Slate Lake with treated tailings water discharging to Slate Creek.

Dolly Varden char (*Salvelinus malma*), pink salmon (*Onchorhynchus gorbuscha*), chum salmon (*O. keta*), cutthroat trout (*O. clarki*), and prickly sculpin (*Cottus asper*) inhabit the reach below the falls barriers on each stream (Konopacky 1992, Biostat 1998). Dolly Varden are the only species occurring upstream of the fish barriers (Biostat 1998).

Figure 1: Location of streams near Kensington Mine included in 2005 Aquatic Resource Surveys. Sediment toxicity testing, resident and anadromous fish surveys, quality of spawning gravel and aquatic vegetations surveys were conducted in Sherman, Johnson and Slate Creeks. Benthic invertebrate monitoring was conducted on Johnson and Slate Creeks.

3.0 Sediment Monitoring

3.1 Introduction

This section summarizes the data generated from sediment toxicity tests, metals analysis of sediments and physical characterization of sediments, as requested by the NPDES permit. Specific tests performed included: (1) 10-day whole sediment toxicity tests on the amphipod *Hyalella azteca,* and the midge *Chironomus tentans,* (2) measures of total organic carbon, total solids, total volatile solids, total sulfide, (3) particle size analysis of sediment, and (4) analysis of metals in the sediment. Deposited stream sediment was collected in the lower reaches of Sherman Creek, Slate Creek and Johnson Creek in early August 2005 prior to construction activity. Metals tend to adhere to fine clay particles, but there a very few areas of fine sediment deposition in any of the streams. A few areas on the stream margins were found with fine deposits of mud. These areas were targeted for sample collection.

3.2 Methods

At each site, a mud sample was collected by personnel wearing latex gloves, using a stainless steel scoop. The mud was shaken through sieves sized at 1.68, 0.42 and 0.15mm to separate coarse and fine sediment. The fine sediment that passed through the smallest diameter sieve was then poured into an Imhoff cone and allowed to settle for 10 minutes. Water was then decanted off the top and the finest sediment left in the bottom of the cone collected for the sample. This process was repeated until approximately 2L of fine sediment was collected.

100ml of the sediment was placed in pre-cleaned glass containers provided by the laboratory (Columbia Analytical Services, Kelso, Washington) and frozen prior to shipping. This sample was analyzed for metal concentration and grain size present. The remainder of the sample was placed in 2L pre-cleaned high-density polypropylene containers and shipped to ENSR, Fort Collins, Colorado for toxicity testing. Sampling equipment (stainless steel scoops, sieves) was cleaned between sites by rinsing with site water and ethyl alcohol.

Columbia Analytica performed physical and metal analyses of the collected sediment. Particle size was determined for each creek by ASTM D422: Standard Test Method for Particle-Size Analysis of Soils. The distribution of particle sizes larger than 75 μm (retained on the No. 200 sieve) was determined by sieving, while the distribution of particle sizes smaller than 75 μm was determined by a sedimentation process using a hydrometer (Table 1).

Table 1. Sediment particle size determination for Sherman, Johnson, and Slate Creek samples.

Sieve Analysis		**Sherman**		**Johnson**		**Slate**	
Sieve Size (mm)		Weight (g)	% Passing	Weight (g)	% Passing	Weight (g)	% Passing
Gravel	19	0	100	0	100	0	100
Gravel	9.5	0	100	0	100	0	100
Gravel, Medium	4.75	0	100	0	100	0	100
Gravel, Fine	2.00	0	100	0	100	0	100
Sand, very coarse	0.85	0.04	99.90	0.03	99.90	0	100
Sand, coarse	0.425	0.02	99.90	0.06	99.80	0.023	99.9
Sand, medium	0.25	0.35	99.20	1.48	96.90	0.585	98.8
Sand, fine	0.11	7.80	84.70	13.47	70.10	7.89	82.8
Sand, very fine	0.08	8.26	69.20	4.12	61.90	7.94	66.8
Hydrometer Analysis		**Sherman**		**Johnson**		**Slate**	
Silt and Clay Particle Diameter (mm)			% Passing		% Passing		% Passing
	0.074		29.7		25.8		34.5
	0.005		8.53		5.76		11.8
	0.001		0		0		0

Slate Creek sediment contained the highest percentage of fine material (35% less than 0.074mm diameter). Approximately the same percentage of fine particles was present in Johnson and Slate Creek samples (26-30%). Around 62% of Johnson Creek sediment, 67% of Slate and 69% of Sherman Creek sediment was smaller than 0.08mm. Only 6% of Johnson, 8.5% of Sherman and 12% of Slate Creek sediment was between 0.001 and 0.005mm (clay).

Total Solids, Total Volatile Solids, Total Sulfide, and Total Organic Carbon were analyzed by EPA methods 160.3M, 160.4M, and PSEP (Table 2). Concentrations of total organic carbon ranged from 1.77% in Johnson Creek sediment to 4.58% in Sherman Creek sediment. Total volatile solids ranged from 3.9% in Johnson Creek sediment to 6.6% in Slate Creek samples. Sulfide was not detected in any of the samples (0.9mg/kg MRL). The laboratory report is included as Appendix 1a.

Table 2. Inorganic parameter analysis for Sherman, Johnson, Slate Creeks

	Total Solids	**Total Volatile Solids**	**Total Sulfide**	**Total Organic Carbon**
Creek	%	%	mg/Kg	%
Sherman	60.6	5.71	< 0.9	4.58
Johnson	69.4	3.86	< 0.9	1.77
Slate	57.7	6.55	< 0.9	4.25

3.3 Sediment Metal Concentration

The metal analyses were conducted using inductivity-coupled plasma-mass spectrometry (ICP-MS). The concentrations of each of 11 metal concentrations (Aluminum (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), and Zinc (Zn)) found in the sediment are given in Table 3. Nine out of the eleven metals appeared to be highest in Lower Sherman (aluminum, cadmium, chromium, copper, mercury, lead, nickel, silver and zinc). Sediment samples from all three creeks were high in aluminum, with Sherman Creek showing the highest concentration at 17,400 mg/kg.

Table 3: Concentrations of metals in stream sediment, August 2005 (mg/kg)

Analyte	Sherman	Johnson	Slate Creek
Aluminum	17,400	15,800	17,200
Arsenic	48.7	63	11.4
Cadmium	0.38	0.1	0.15
Chromium	31.7	26.6	23.3
Copper	94.7	83.1	37.1
Lead	27.2	6.27	12.9
Mercury	0.21	0.04	0.1
Nickel	29	18	22.8
Selenium	2	1.0	1.8
Silver	0.37	0.13	0.18
Zinc	111	58	97.1

Numbers in red are the highest concentrations for each element, while numbers in blue are the lowest.

3.4 Sediment Toxicity Testing

Toxicity testing was carried out by ENSR International in Fort Collins, Colorado. Any endemic organisms in the sediment were removed prior to the testing. Eight replicates of stream sediment with continuous renewal of overlying water were used per treatment, with two types of laboratory control sediment used for comparison. The primary control sediment was silica sand and the second control sediment consisted of a smaller grain size and higher organic matter content (Appendix 1b, 1c). *Chironomus tentans* 3rd instar larvae the amphipod *Hyalella azteca* were used for 10 day toxicity tests using survival and growth (ash-free dry weight per organism) as endpoints.

Physical parameters including dissolved oxygen temperature, pH, hardness, alkalinity, conductivity, and ammonia were monitored throughout the tests (Appendix 1b, c). There were no significant differences in survival or growth between the test sediments and the laboratory controls. Sherman Creek sediment appeared to show the highest survival rate and lowest growth rate of all three stream sediments for both test species (Tables 4a, 4b) but these results are not significantly different from control samples, despite high levels of aluminum in the sediment. The relevant QA/QC information can be found in the lab reports (Appendix 1b, 1c).

Table 4a: Survival of organsisms after 10-day exposure to sediment.

Biological Data			
Collection Date	Sample ID	*Chironomus tentans* Survival (%)	*Hyalella azteca* Survival (%)
8/9/05	Sherman Creek	**75**	**93.75**
8/3/05	Johnson Creek	**67.5**	**85**
8/8/05	Slate Creek	**65**	**75**
	Sand - control	**87.5**	**91.25**
	Lab Sediment	**71.2**	**80**

Table 4b: Growth of organisms after 10-day exposure to sediment.

Sample ID	Ash Free Dry Weight (mg) *per original organism*	Ash Free Dry Weight (mg) *per surviving organism*	*Chironomus tentans* Growth	% Growth
Sherman Creek	1.178	1.624	0.45	37.9
Johnson Creek	1.19	1.805	0.62	51.7
Slate Creek	0.918	1.442	0.52	57.1
Sand - control	1.122	1.287	0.17	14.7
Lab Sediment	1.351	2.004	0.65	48.3

Sample ID	Ash Free Dry Weight (mg) *per original organism*	Ash Free Dry Weight (mg) *per surviving organism*	*Hyalella azteca* Growth	% Growth
Sherman Creek	0.061	0.064	0.003	4.9
Johnson Creek	0.049	0.057	0.008	16.3
Slate Creek	0.039	0.055	0.016	41.0
Sand - control	0.046	0.05	0.004	8.7
Lab-Sediment	0.034	0.041	0.007	20.6

4.0 Benthic Invertebrates

4.1 Aquatic Invertebrate Collection

Extensive benthic invertebrate surveys were carried on Sherman Creek in 1995 (Konopacky 1996). In 2005, benthic invertebrates were collected from the streambed in Johnson Creek at the JS-1 flow monitoring site, upstream of the upper bridge crossing on April 20, and from Slate Creek downstream from SLA on April 27, 2005. These sites were used in 2004 invertebrate monitoring (Aquatic Science 2004). Each reach was examined for all possible sampling sites, namely riffles with substrate particles greater than 20cm and water depth was less than 0.5m. Every 3rd or 4th potential site was sampled until a total of 6 samples were obtained for the reach. Samples were collected using a 0.093m^2 Surber sampler equipped with 300μm mesh, placed in labeled whirlpak bags and preserved with 70% ethyl alcohol.

4.2 Invertebrate identification

Sorting and identification of invertebrates was conducted by Aquatic Science Inc. in Juneau, Alaska, who performed previous invertebrate monitoring for Kensington samples. Invertebrates were identified to genus level using appropriate taxonomic keys (Merritt & Cummins 1996, Thorp 2001, Clarke 1981) and numbers of each genus recorded for each sample. The species composition of samples is given in Table 5.

4.3 Invertebrate Data Analysis

The area of the Surber sampling device is 0.093 m^2. This was used to express densities of invertebrates as total numbers of invertebrates per m^2. Shannon-Weaver Diversity (H) and Evenness (E) indices were calculated using the following equations:

$$H = \text{sum} (Pi \log10 \{Pi\})$$

$$E = H/\log10 (S)$$

Where Pi is the number of organisms of a given species divided by the total number of organisms in the sample (the proportion of the sample comprised of species i), and S is the number of species present in the sample.

Diversity indices are presented in Table 6. The relative abundance of the EPT taxonomic orders, Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddis flies) in each sample was enumerated and the number of EPT taxa was expressed as a proportion of the total number of taxa present.

4.4 Taxonomic Classification

Slate Creek samples contained a total of 789 invertebrates from 26 genera, including 19 EPT taxa (Table 5). Non-EPT taxa included 4 Chironomidae genera (non-biting midges), a single genera of ceratopogonidae (biting midges), and a simulid taxa (black flies). Johnson Creek samples contained 717 invertebrates from 36 genera composed of 26 EPT taxa, 5 Chironomidae taxa, two Tipulidae (crane flies), a ceratopogonidae and a Collembola (springtail).

Densities of invertebrates in Slate Creek ranged from 700 invertebrates per m^2 to 2280/m with a mean of 1400/ m^2. Johnson Creek densities ranged from 600 to 2280/ m^2 with a mean of 1285/ m^2. On average, the ratio of EPT taxa to other genera was higher in Johnson Creek (0.8) compared to Slate Creek (0.6). Despite the higher number of taxa in Johnson Creek, Shannon-Weaver diversity indices were not much greater due to the presence of a few dominant species of mayfly such as Baetis and Cinygmula spp.

The most abundant genera in Slate Creek were the mayflies *Baetis* and *Epeorus*, the blackfly larvae *Prosimulium* and the midge *Tanytarsus*. In Johnson Creek, the mayflies *Baetis* and *Cinygmula* and *Drunella*, the caddis fly *Rhyacophila* and the midge *Eukiefferiella*, were the most numerous.

Table 5: Species Composition of Benthic Invertebrate Samples from Johnson and Slate Creeks, April 2005.

Taxonomic Group				Johnson	Slate
Class	Order	Family	Genus	Mean	Mean
Insecta	Ephemeroptera	Baetidae	Baetis	47.2	15
			Acentrella	0.3	0
			Procleon	0.2	0
			Diphetor	0	0.5
		Heptageniidae	Epeorus	3.7	12.5
			Cinygmula	15.2	4.2
			Rithrogena	3.3	1
		Ephemerellidae	Attenella	2.5	0.2
			Drunella	9.5	0.2
		Leptophlebiidae	Paraleptophlebia	1.8	4.7
	Plecoptera	Chloroperlidae	Neaviperla	0.7	0.7
			Haploperla	1.7	2.3
			Alaskaperla	0.5	0.5
			Nemoura	1.3	0.5
			Kathroperla	0.8	0
			Plumiperla	1.5	0
			Paraperla	0.5	0
		Leuctridae	Despaxia	0.5	0.2
			Hesperoperla	0	0.2
		Nemouridae	Zapada	2.2	0.2
			Shipsa	0.8	0
		Capniidae	Capnia	0.3	0
			Paracapnia	0	0.5
			Allocapnia	2.0	0
	Trichoptera	Brachycentridae	Amniocentus	0.2	0
			Eobrachycentrus	0.2	0
			Micrasema	0	1.2
		Hydropsychidae	Parapsyche	1.8	0
		Glossosomatidae	Glossoma	1.7	0
		Polycentropidae	Polycentropus		0.2
		Rhyacophilidae	Rhyacophila	5.5	0.3
	Diptera	Chironomidae			
	sub-family	Orthocladiinae	Eukiefferiella	8.3	2.2
			Pagasta	0.8	1.2
			Tokunaga	0.8	0
			Tvetania	0.3	4.4
			Corynoneura	0.7	0
		Tanytarsini	Tanytarsus	0	14.2
		Tipulidae	Polymera	0.3	0
			Triogma	0.2	0
	Brachycera	Pelecorhynchidae	Glutops	0.2	0
		Ceratopogonidae	Probezzia	0.0	0.2
		Simuliidae	Prosimulium	1.8	52.7
	Collembola	Mackenziellidae	Mackenziella	0.2	0
Bivalva	Sphaeriidae	Psidiinae	Psidium (pea clam)	0	12.7

Table 6: Diversity and Evenness Indices for Benthic Invertebrates in Slate and Johnson Creeks 2005.

	Density (inverts/m^2)	Shannon-Weaver Diversity	Evenness	Total taxa (Genera)	EPT (# of taxa)	Ratio of EPT to other taxa
Slate						
1	978.5	0.69	0.62	13	8	0.6
2	1354.8	0.79	0.69	14	8	0.6
3	698.9	0.62	0.62	10	6	0.6
4	2752.7	0.4	0.57	15	9	0.6
5	1408.6	0.65	0.94	13	7	0.5
6	1290.3	0.66	0.56	15	10	0.7
Mean	**1414.0**	**0.6**	**0.7**	**13.3**	**8.0**	**0.6**
Johnson						
1	1064.5	0.3	0.27	13	10	0.8
2	602.2	0.87	0.74	15	13	0.9
3	1301.1	0.61	0.56	12	9	0.8
4	1021.5	0.71	0.58	17	13	0.8
5	1440.9	0.85	0.69	17	15	0.9
6	2279.6	1.12	0.8	25	18	0.7
Mean	**1284.9**	**0.7**	**0.6**	**16.5**	**13.0**	**0.8**

Samples from Johnson Creek contained a slightly higher proportion of Ephemeroptera, Plecoptera and Trichoptera (average of 80%) than Slate Creek (average of 60%), (Table 6). Johnson Creek samples contained 9 species of mayfly, 12 species of stonefly and 5 species of caddis fly, while Slate Creek samples contained 8 species of mayfly, 8 stonefly species and 3 caddis taxa.

5.0 Resident Fish Population

5.1 Delineation of Strata

Population estimates of resident fish were conducted in 2005 in the Lower, Middle and Upper strata of Sherman, Johnson and Slate Creeks (Figures 2, 3). Each strata is 360m in length. Sherman Creek strata were designated during aquatic resource surveys in 1998 (Aquatic Science Inc. 1998). Lower Sherman extends from the stream mouth to the barrier falls 360m upstream. Both Middle and Upper Sherman are located above the barrier falls and are thereby inaccessible to ocean-dwelling fish. Middle Sherman extends 360m downstream from the confluence of Sherman Creek and Ophir tributary. Upper Sherman extends 360m upstream from the road bridge across Upper Sherman Creek.

Lower Johnson begins at the forest/meadow border approximately 400m upstream from the confluence with Berners Bay. Middle Johnson begins at the lower road bridge and continues 360m upstream. Upper Johnson is located upstream of the mill site pad and above a braided section of river, in the Jualin basin. Lower Slate begins at the forest edge; Middle Slate begins 100m above the barrier falls; Upper Slate is located on the creek between Upper and Lower Slate lakes and begins 100 m upstream from Lower Slate Lake. All reaches are 360m long.

Table 7: GPS Coordinates of Sherman, Johnson and Slate Strata

Strata	GPS Coordinates	Elevation
Lower Sherman	N 58°52.121 W 135°08.506’	12 ft
Middle Sherman	N 58°52.041’ W 135°06.961’	420 ft
Upper Sherman	N 58°51.785’ W 135°06.118	720 ft
Lower Johnson	N 58°49.437’ W 135°59.966	12 ft
Middle Johnson	N 58°49.620’ W 135°01.842	525 ft
Upper Johnson	N 58°50.807’ W 135°03.015	800 ft
Lower Slate	N 58°47.754’ W 135°02.332	15 ft
Middle Slate	N 58°48.468’ W 135°02.329	350 ft
Upper Slate	N 58°48.847’ W 135°02.418	800 ft

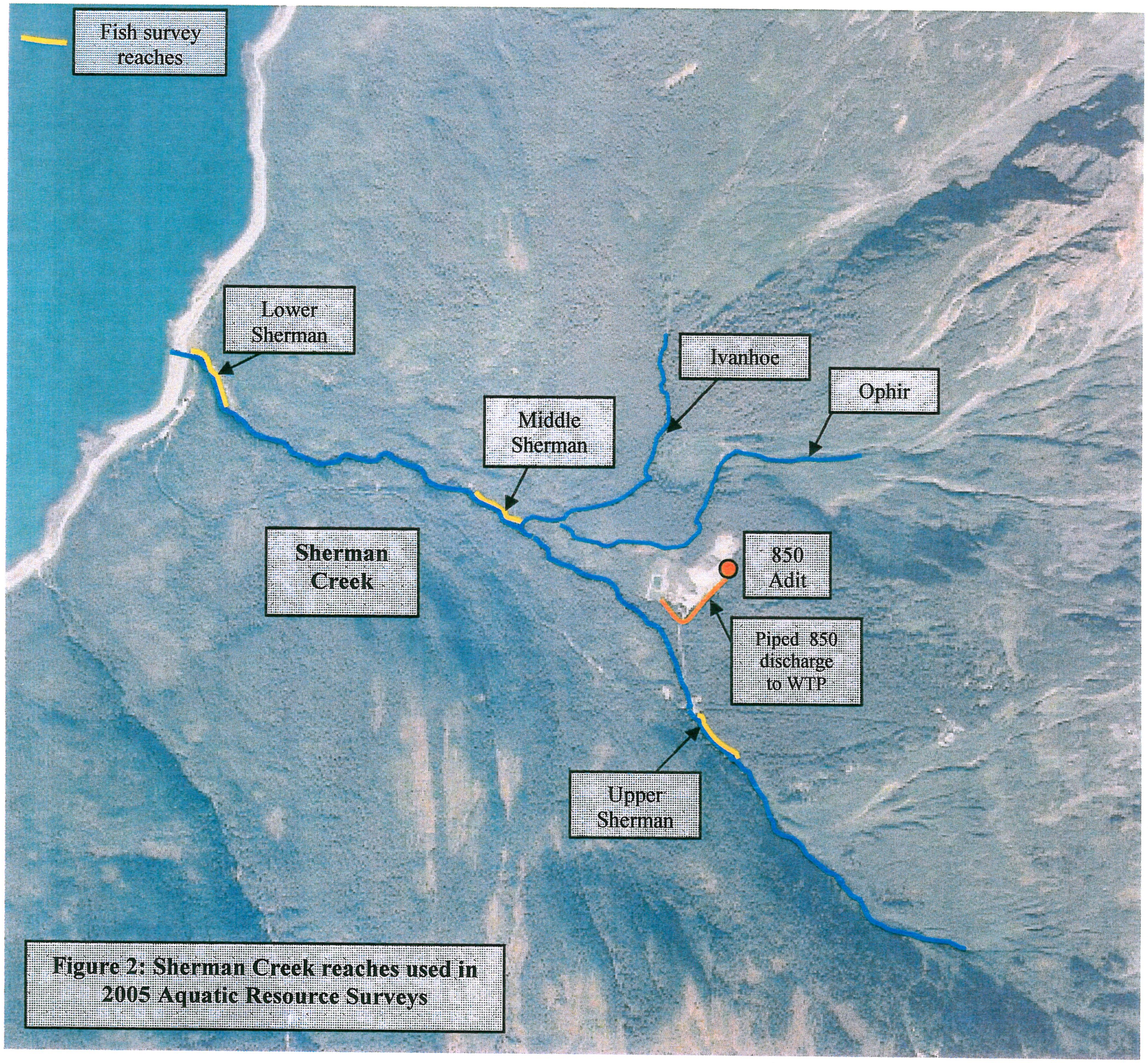


Figure 2: Sherman Creek reaches used in 2005 Aquatic Resource Surveys

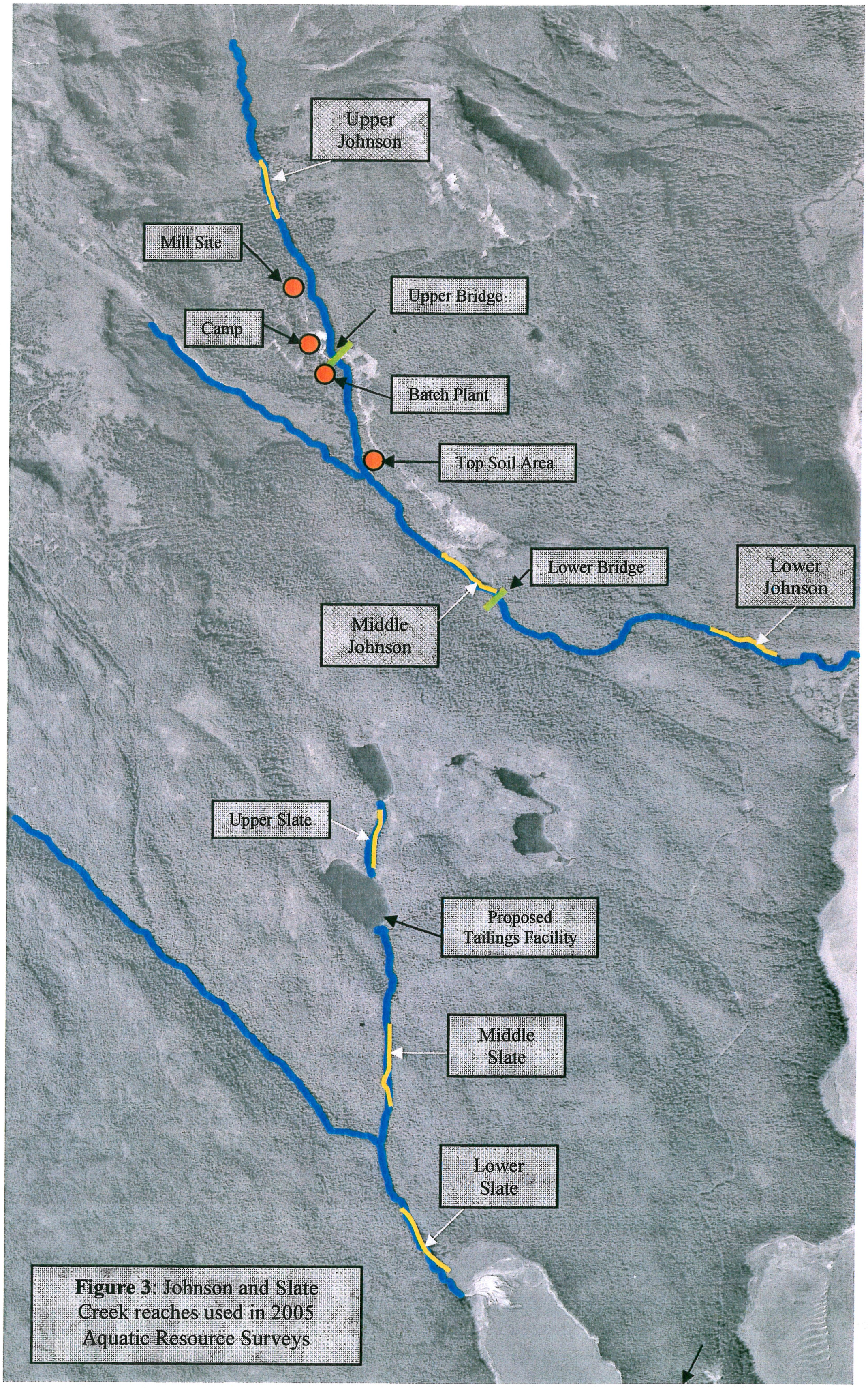


Figure 3: Johnson and Slate Creek reaches used in 2005 Aquatic Resource Surveys

5.2 Resident fish population survey methods

The number of fish within each stratum was estimated using the methods of Hankin and Reeves (1988) as in Konopacky (1995). The 2005 resident fish surveys were conducted in Sherman Creek on July 10, 11 and 12, Johnson Creek on July 14 and 15, and Slate Creek on July 17, 18 and August 22. For each stratum, stream habitat units were first categorized as riffle, pool, glide or cascade following the classifications of Bisson et al (1981). At least every third riffle, pool and glide was selected for snorkeling.

One team member, equipped with dry suit and snorkel, quietly entered the water at the downstream end of a selected unit and proceeded upstream observing fish underwater. A second team member, following behind to minimize disturbance to fish, measured the length of each habitat unit to the nearest 0.1m using a metric hip chain, and recorded the fish counts. Habitat unit width was measured using a 15m tape measure. Water temperature, pH and conductivity were measured at the start of each stratum.

The accuracy of visual counts was verified by electro-fishing at least one unit of each habitat type previously snorkeled. Prior to electro-fishing, ¼ inch seine netting was place across the creek at the downstream end of each reach to prevent any uncaptured, stunned fish from passing downstream. Minnow traps baited with cured salmon eggs were set in high density fish areas identified by the diver. This allowed some fish to be removed and counted prior to electro-fishing thereby minimizing effects of the electric current on the fish population. A three-member team proceeded upstream using a Smith-Root gasoline-powered backpack electro-fishing unit with output waves designed to minimize impact on fish. All stunned fish were counted and captured using dip nets for determination of condition factor. Captured fish were anesthetized in a solution of MS222 (Tricanemethane Sulphonate) as recommended by the American Veterinary Association, weighed to the nearest 0.1g and their total length measured to the nearest 1mm. The fish were then placed in a container of fresh stream water to recover before being returned to the habitat unit from which they were captured.

Figure 4: Photographing Dolly Varden (***Salvelinus malma***) in Lower Sherman.

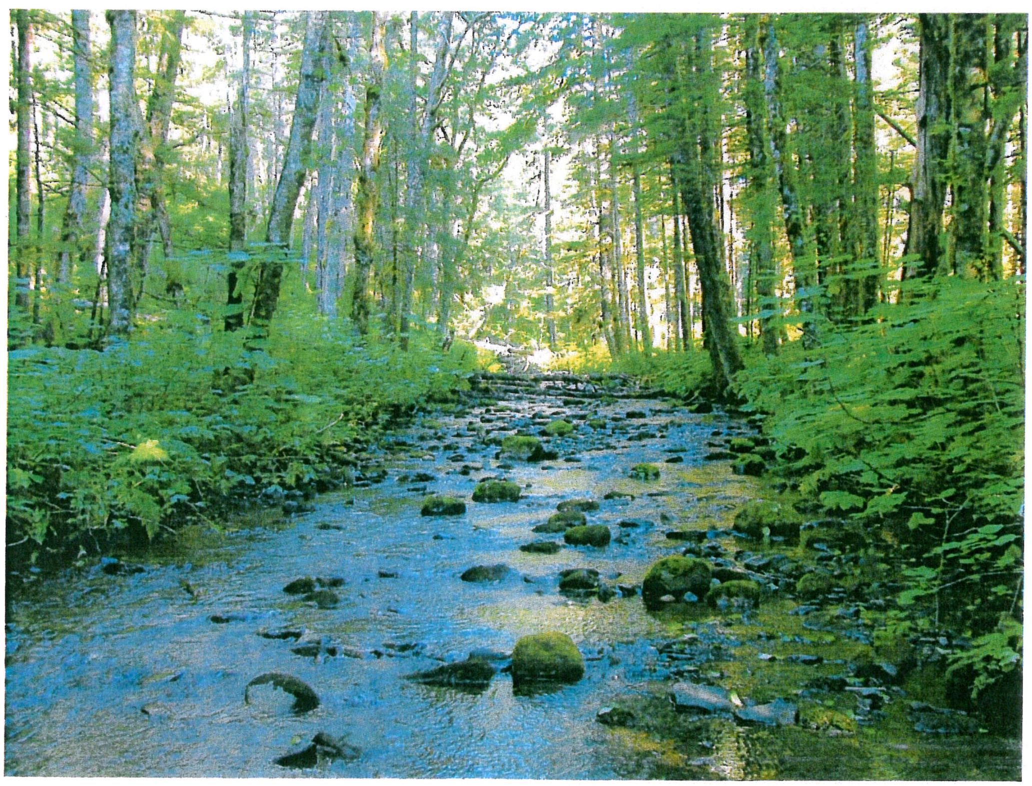


Figure 5: Lower Slate Creek.

5.3 Data analysis methods

The number of each fish species within a stratum was estimated by first applying a correction factor to the visual counts based on electro-shocking counts. These corrected counts were then extrapolated over the total number of units of each habitat type within a stratum. Standard deviations and 95% confidence intervals for the population estimates were determined for each stratum using equations (5) through (11) in Hankin & Reeves (1988). Minimum detectable differences between population estimates were calculated by performing analysis of variance on fish counts for each habitat unit. The dimensions of each habitat unit in each stratum are given in Appendix 2a. The total area of each habitat type was calculated (Appendix 2b) and used in the computation of fish densities.

5.4 Population estimates

Counts made by visual observation and by electro-shocking are summarized in Table 8. Population estimates by habitat type and by stratum are presented in Table 9 and illustrated in Figure 6. Dolly Varden were found in all strata except Lower Slate, while cutthroat trout were only present in the lower reaches of each creek, below the falls barriers. Cutthroat numbers were highest in Lower Sherman and lowest in Lower Johnson where Dolly Varden dominated the population. The precision of population estimates was examined by expressing 95% confidence intervals as a percentage of the estimated population size (Table 9, Figure 6). The lower the percentage the more precise the population estimates.

The 39 Dolly Varden captured by electro-fishing and minnow trapping in the three strata of Sherman Creek represented 11.0% of the estimated Dolly Varden population of Sherman Creek. The 11 cutthroat trout captured in Lower Sherman represented 8.1% of the estimated Sherman Creek cutthroat population. The 42 Dolly Varden and 3 cutthroat captured in Johnson Creek represented 20.8% and 27.3% respectively of the estimated populations of Johnson Creek strata. The 14 Dolly Varden and 5 cutthroat trout captured in Slate Creek composed 15.4% and 13.2% of the Slate Creek populations. Actual counts of fish obtained by snorkeling and electro-fishing in each habitat unit are presented in Appendix 2a.

Table 8: 2005 Resident Fish Counts by Habitat Type in Sherman, Johnson and Slate Creeks.

Stream Reach	Habitat Type	Total Units (N) in stratum	Snorkeling: Units (n) snorkled	Snorkeling Numbers Observed: Dolly	Snorkeling Numbers Observed: Cutthroat	Electrofishing: Units (n') fished	Electrofishing Numbers Observed: Dolly	Electrofishing Numbers Observed: Cutthroat
Lower Sherman	Riffle	30	13	8	18	6	5	12
	Pool	23	12	55	42	6	18	25
	Glide	4	3	3	5	3	3	6
	All Units	57	28	66	65	15	26	43
Middle Sherman	Riffle	22	9	9	0	4	5	0
	Pool	35	17	51	0	7	17	0
	Glide	0	na	na	na	na	na	na
	All Units	57	26	60	0	11	22	0
Upper Sherman	Riffle	29	12	7	0	5	5	0
	Pool	35	22	27	0	10	22	0
	Glide	4	3	2	0	3	3	0
	All Units	68	37	36	0	18	30	0
Lower Johnson	Riffle	17	9	5	3	6	5	2
	Pool	14	10	63	3	5	9	4
	Glide	7	5	0	0	3	0	0
	All Units	38	24	68	6	14	14	6
Middle Johnson	Riffle	19	9	3	0	5	2	0
	Pool	12	9	4	0	5	5	0
	Glide	5	4	1	0	3	2	0
	All Units	36	22	8	0	13	9	0
Upper Johnson	Riffle	16	9	3	0	5	2	0
	Pool	16	10	32	0	5	23	0
	Glide	13	9	4	0	3	4	0
	All Units	45	28	39	0	13	29	0
Lower Slate	Riffle	24	12	0	2	5	0	2
	Pool	17	12	0	20	6	0	8
	Glide	2	2	0	0	2	0	0
	All Units	43	26	0	22	13	0	10
Middle Slate	Riffle	12	4	0	0	4	0	0
	Pool	37	18	1	0	8	1	0
	Glide	0	0	0	0	0	0	0
	All Units	49	22	1	0	12	1	0
Upper Slate	Riffle	26	11	5	0	4	6	0
	Pool	22	14	24	0	6	14	0
	Glide	12	8	15	0	3	5	0
	All Units	60	33	44	0	13	25	0

Table 9: Population estimates by species, habitat type and stratum, 2005.

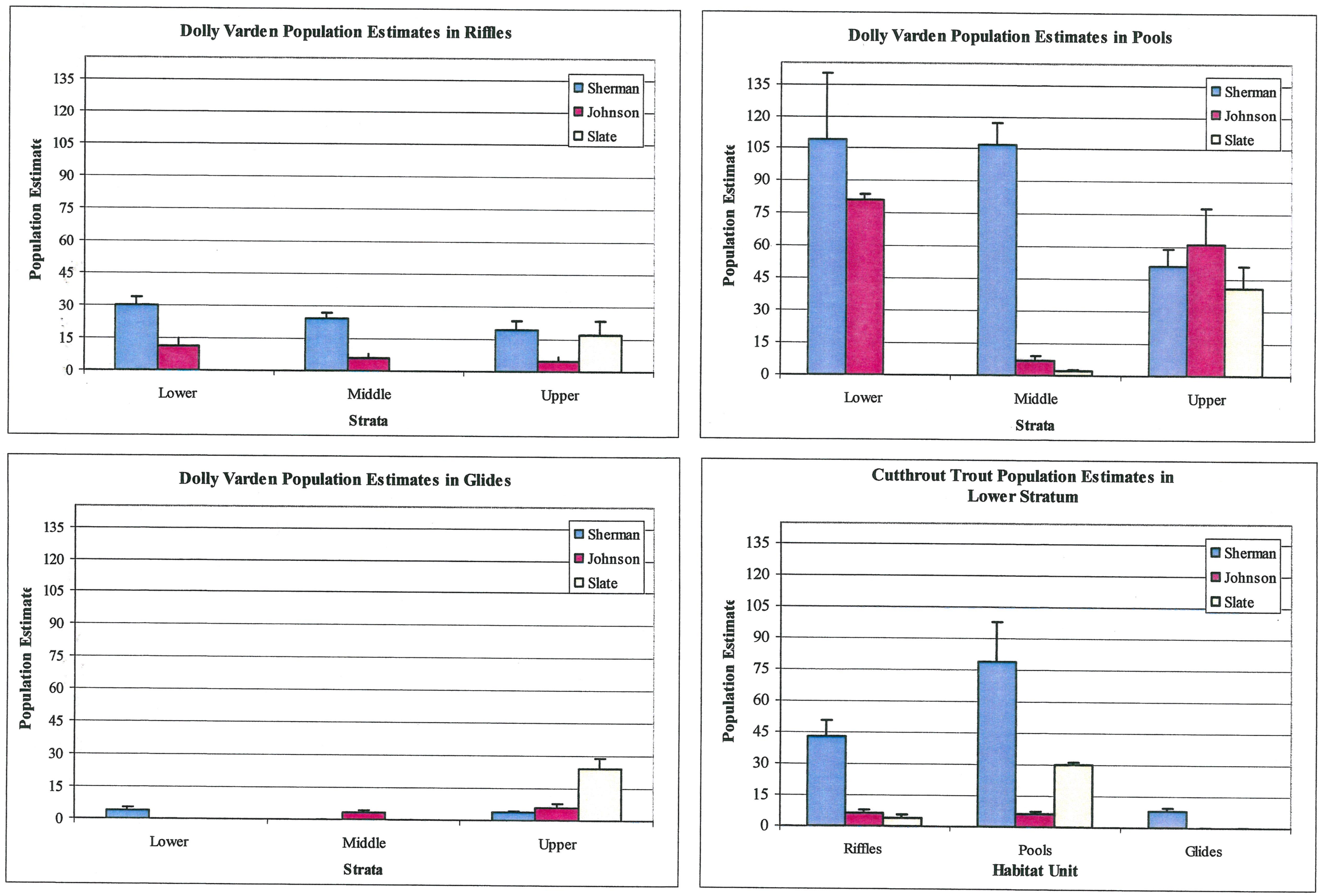
Reach	Habitat Unit	Estimate	C.I.	Precision (%)	Std. Dev
Lower	Riffles	30	3.94	13.1	2.743
	Pools	109	31.27	28.7	7.434
	Glides	4	1.51	37.8	1.154
	All Units	**145**	**33.86**	**23.4**	**9.646**
Middle	Riffles	24	3.02	12.6	1.754
	Pools	107	9.81	9.2	3.640
	Glides	na	na	na	na
	All Units	**132**	**8.1**	**6.1**	**4.677**
Upper	Riffles	19	4.46	23.5	2.806
	Pools	51	8.1	15.9	4.404
	Glides	4	0.21	5.3	0.433
	All Units	**77**	**14.3**	**18.6**	**6.661**

Reach	Habitat Unit	Estimate	C.I.	Precision (%)	Std. Dev
Lower	Riffles	11	3.83	34.8	2.421
	Pools	81	2.86	3.5	2.199
	Glides	0	-	-	-
	All Units	**111**	**10.03**	**9.0**	**5.006**
Middle	Riffles	6	2.07	34.5	1.780
	Pools	7	2.01	28.7	1.753
	Glides	3	1.09	36.3	1.054
	All Units	**16**	**4.96**	**31.0**	**3.447**
Upper	Riffles	5	1.94	38.8	1.722
	Pools	61	16.66	27.3	5.185
	Glides	6	2.2	36.7	1.836
	All Units	**75**	**34.09**	**45.45**	**9.506**

Slate Creek Dolly Varden					
Reach	Habitat Unit	Estimate	C.I.	Precision (%)	Std. Dev
Lower	Riffles	0	-	-	-
	Pools	0	-	-	-
	Glides	0	-	-	-
	All Units	**0**	-	-	-
Middle	Riffles	0	-	-	-
	Pools	2	0.93	46.5	1.418
	Glides	na	na	na	na
	All Units	**2**	**0.81**	**40.5**	**1.427**
Upper	Riffles	17	6.55	38.5	1.722
	Pools	41	9.8	23.9	5.185
	Glides	24	5.22	21.8	1.836
	All Units	**89**	**16.2**	**18.2**	**6.890**

Cutthroat Trout					
Creek	Habitat Unit	Estimate	C.I.	Precision (%)	Std. Dev
Sherman	Riffles	43	7.38	17.2	3.754
Lower	Pools	79	18.8	23.8	5.768
	Glides	8	1.52	19.0	1.159
	All Units	**136**	**25.28**	**18.6**	**8.334**
Johnson	Riffles	6	1.65	27.5	1.587
Lower	Pools	6	1.29	21.5	1.440
	Glides	0	-	-	-
	All Units	**11**	**2.1**	**19**	**2.303**
Slate	Riffles	4	1.48	37.0	1.618
Lower	Pools	30	1.22	4.1	1.469
	Glides	0	-	-	-
	All Units	**38**	**3.59**	**9.4**	**3.058**

Figure 6: 2005 Population Estimates of Resident Fish in Sherman, Johnson and Slate Creeks by species, habitat type and stratum. Error bars represent 95% upper confidence limits.



5.5 Minimum detectable differences among population estimates.

By specifying the significance level and samples size for an analysis of variance, it is possible to determine what the smallest detectable difference between population means will be. Minimum detectable differences in mean numbers of fish counted in each stratum and in each habitat type were calculated using the following equation:

$$\delta = \sqrt{\frac{2\,k\,s^2\,\phi^2}{n}}$$

where δ is the minimum detectable difference between means, k is the number of groups being compared, s^2 is the mean square error derived from analysis of variance, n is the sample size (number of habitat units), and ϕ is a quantity read from tables, incorporating k, n, and the probabilities of committing a Type I and Type II error (Zar 1999). A significance level (α) of 0.05, and a statistical power ($1 - \beta$) of 0.8 were specified for the analysis, determining that differences between means at a 95% significance level could be detected 80% of the time.

Mean number of fish in each habitat type were used to compute minimum detectable differences between strata (Table 10). A difference in means of 1 to 2 fish per habitat unit was detectable among riffles in all strata. Minimum detectable differences were greater for pool and glides, reflecting the higher variation in numbers of fish in these habitats. Some pools in Johnson Creek held large numbers of fish, while no fish were observed in other pools. Glide habitat was also limited, restricting the number of units that can be surveyed. The ability to detect small differences in numbers of fish is important in detecting changes in the population from year to year.

Table 10: Mean number of Dolly Varden per habitat type and minimum detectable differences (MDD) between means for different strata.

	Dolly Varden								
	Sherman Creek			Johnson Creek			Slate Creek		
Strata	**Riffle**	**Pool**	**Glide**	**Riffle**	**Pool**	**Glide**	**Riffle**	**Pool**	**Glide**
Lower	1	4.75	1	0.667	5.818	0	0	0	0
Middle	1.111	2.75	NA	0.333	0.556	0.667	0	0.125	NA
Upper	0.583	1.524	1	0.444	4.111	1.333	1.5	2.333	1.667
MDD	**1.55**	**3.53**	**0.00**	**0.85**	**10.99**	**2.94**	**0.80**	**2.49**	**9.81**

	Dolly Varden								
	Lower Strata			Middle Strata			Upper Strata		
Strata	**Riffle**	**Pool**	**Glide**	**Riffle**	**Pool**	**Glide**	**Riffle**	**Pool**	**Glide**
Sherman	1	4.75	1	1.111	2.75	NA	0.583	1.524	1
Johnson	0.667	5.818	0	0.333	0.556	0.667	0.444	4.111	1.333
Slate	0	0	0	0	0.125	NA	1.5	2.333	1.667
MDD	**2.33**	**17.41**	**2.55**	**1.60**	**2.14**	**NA**	**1.62**	**5.22**	**4.95**

	Cutthroat Trout		
	Lower Strata		
Strata	**Riffle**	**Pool**	**Glide**
Sherman	1.429	3.727	2.667
Johnson	0.333	0.364	0
Slate	0.154	1.75	0
MDD	**1.12**	**3.16**	**1.47**

Figure 7: Dolly Varden in Lower Sherman

5.6 Fish density

Due to differences in the size of habitat areas sampled, population estimates were converted to numbers of fish per unit area for comparisons between strata and habitat types. Densities of both fish species tended to be higher in pool or glide habitat, than riffle habitat in both streams (Table 11).

Table 11: Densities of fish by species, stratum and habitat type.

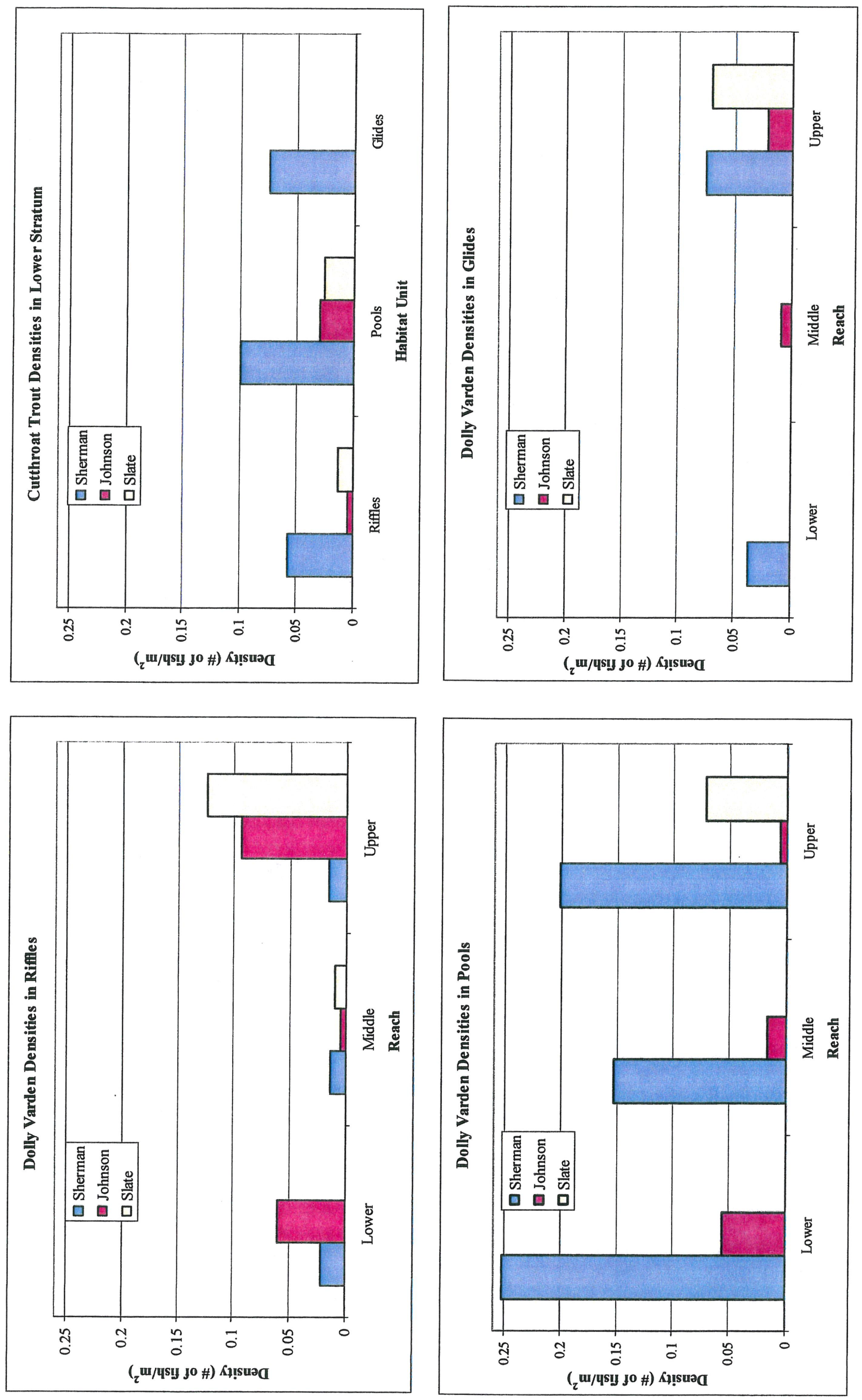
	Fish Density (# of fish/m^2)					
	Dolly Varden			Cutthroat Trout		
Strata and Creek	Riffles	Pools	Glides	Riffles	Pools	Glides
Lower Sherman	0.022	0.252	0.037	0.057	0.099	0.075
Middle Sherman	0.013	0.153	-			
Upper Sherman	0.016	0.202	0.075			
Lower Johnson	0.060	0.056	0.000	0.004	0.031	0
Middle Johnson	0.004	0.016	0.009			
Upper Johnson	0.093	0.006	0.021			
Lower Slate	0.000	0.000	0.000	0.0140	0.0263	0
Middle Slate	0.010	0.000	-			
Upper Slate	0.124	0.072	0.071			

Dolly Varden and cutthroat density was highest in Sherman pools (Figure 8). Among riffles, Upper Slate showed the highest densities of Dolly Varden, while among glides, Upper Sherman and Upper Slate densities were high. Cutthroats were only observed in the lower reaches of each stream.

Table 12: Densities of all salmonids in Sherman, Johnson and Slate Creeks.

	Fish Density (# of fish/m^2)		
	Total Salmonids		
Strata and Creek	Riffles	Pools	Glides
Lower Sherman	0.079	0.351	0.112
Middle Sherman	0.013	0.153	-
Upper Sherman	0.016	0.202	0.075
Lower Johnson	0.065	0.087	0.000
Middle Johnson	0.004	0.016	0.009
Upper Johnson	0.093	0.006	0.021
Lower Slate	0.014	0.026	0.000
Middle Slate	0.010	0.000	-
Upper Slate	0.124	0.072	0.071

Figure 8: Densities of Resident Fish in Sherman, Johnson and Slate Creeks, 2005



5.7 Fish condition

Fish condition was determined from lengths and weights of fish measured in the field. Since condition factor varies with fish age, comparisons were only made between fish of similar size. The histograms in Figure 9 show the range in size of fish captured in the two creeks. Only fish 70mm or larger were included in the calculation of mean condition factor by stratum. The lengths and weights of fish in the chosen size class were used to calculate Fulton's condition factor (K) using the equation given in Anderson & Gutreuter (1983):

$$K = W/L^3 \times 10{,}000$$

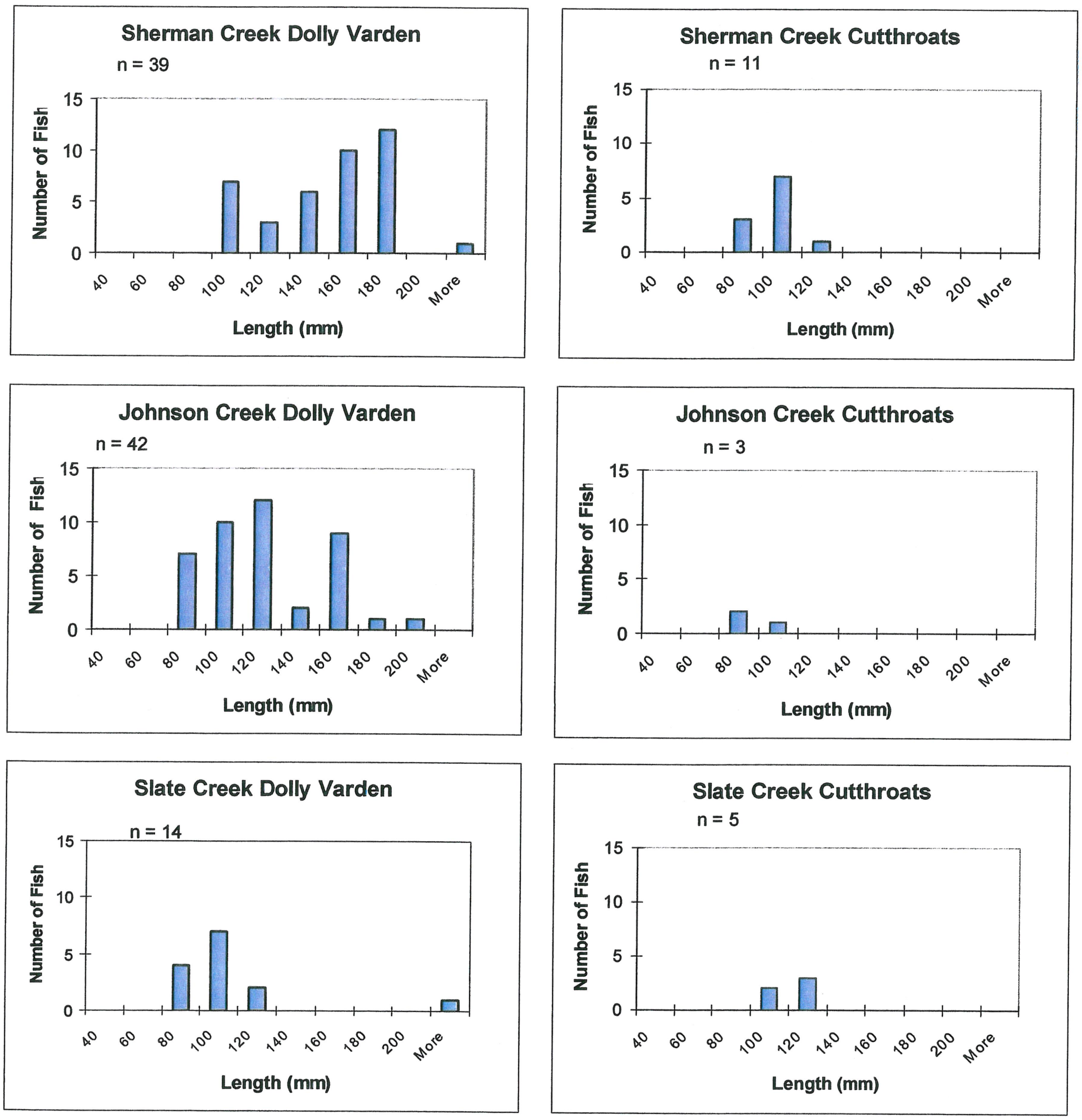
W = weight in g; L = total length in mm

The length, weight and condition factor of each fish are presented in Appendix 2c. Mean condition factors by stratum are presented in Table 13.

Table 13: Mean condition factor of Dolly Varden and cutthroats by stratum.

		Sherman		Johnson		Slate	
		Mean K	95% C.I.	Mean K	95% C.I.	Mean K	95% C.I.
Dolly Varden	Low	0.845	0.048	0.755	0.045	na	na
	Mid	0.77	0.044	0.819	0.034	0.713	na
	Upper	0.861	0.033	0.833	0.037	0.782	0.02
Cutthroat	Low	0.934	0.049	0.747	0.024	0.836	0.023

Figure 9: Length-frequency histograms for Dolly Varden and cutthroat trout captured in Sherman, Johnson and Slate Creeks in 2005.



6.0 Anadromous Fish Population

6.1 Surveys and Analysis

Counts of migrating adult salmon were made once a week in the lower reaches of Sherman, Johnson and Slate creeks from July 21 to October 25, 2005. Prior to the first survey, flagging was placed along one bank of at 50m intervals (Sherman Creek) or 100m intervals (Slate Creek). Each survey on Sherman and Slate Creeks was conducted by biologists on foot, who began at the intertidal zone and proceeded upstream along the bank, recording live and dead salmon species present in each section. Johnson Creek was surveyed using a combination of foot surveys and aerial surveys from a helicopter. Large numbers painted on sheet metal are located on various log jams and can be read from the air to locate reaches. Approximate stream flow (low, average high) and water clarity (visibility of fish) were noted at the beginning of each survey. Water clarity of Johnson Creek was impaired in late August, affecting the number of salmon observed at this time.

The data gathered from the surveys was used to determine the abundance and distribution of spawners in the streams, as well as the timing of the spawning run. Total escapement for pink salmon was estimated using the method of Neilson and Geen (1981), where the sum of all weekly counts is divided by the average residence time of adult spawners in the stream. Since each weekly count includes some fish counted in the previous survey, an adjustment was made to avoid overestimation of escapement. The number of times an individual fish may have been counted during consecutive surveys is assumed to equal the average residence time. A residence time of two weeks was used to compute escapement, as this has been used in previous studies in the area (Biotec 1998, USDA 1997). In a tagging study conducted by Pentec (1990), the residence time of pink salmon spawners in Sherman Creek ranged from one to three weeks.

6.2 Adult Salmon Counts

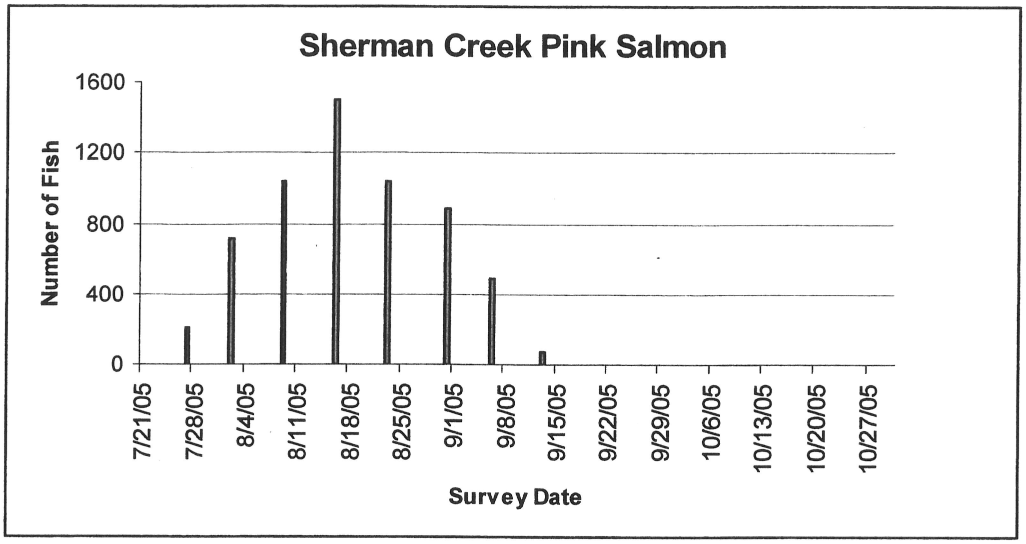
Weekly counts of adult salmon for 2005 are presented in Appendix 3. Figures 10 and 11 show the magnitude and timing of the pink and chum salmon spawning runs in Sherman, Johnson and Slate Creeks. Pink salmon were observed in Sherman Creek from July 27 to September 21 with a maximum of 1500 individuals observed on August 16. Three chum salmon was observed in Sherman Creek on July 27 and 4 chums on August 2. No coho salmon were observed in Sherman Creek. In Johnson Creek, pink salmon were observed from July 27 to September 7, with numbers peaking at 1940 fish on August 16. Around 375 chum salmon were observed in Johnson Creek from July 27 to August 16. Approximately 1150 pinks were observed in Slate Creek from July 27 to September 7, 2005, but only 4 chums were observed in mid-August, and 4 cohos in mid-October. Numbers of pink salmon reached a peak around mid-August in each stream. The magnitude of the pink salmon escapement peak in Sherman and Johnson Creeks was around 5 times that in Sweeny Creek (Table 14). Chum salmon escapement was very low in Sherman and Slate Creeks.

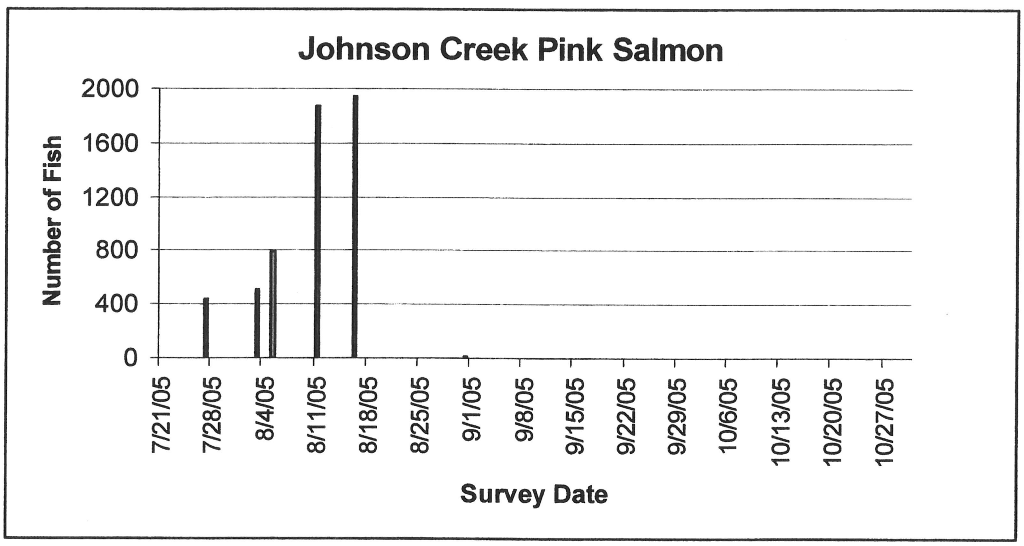
The distribution of salmon in each stream throughout the surveys is shown in Figure 12. In Sherman Creek, pink salmon seemed fairly well distributed throughout the stream from the intertidal reach to the falls. In Johnson Creek pink salmon were mostly observed in reaches 1 to 5. In Sweeny Creek, large numbers of pink salmon were observed in the first 200m of the stream and further upstream from 500 to 800m.

Table 14: Salmon Escapment in Sherman, Johnson and Slate Creeks in 2005.

	Salmon Escapment		
	Sherman Creek	**Johnson Creek**	**Slate Creek**
Pink	**2973**	**2782**	**574**
Chum	**8**	**187**	**2**
Coho	**0**	**78**	**2**

Figure 10: Weekly Counts of Pink Salmon in Sherman, Johnson and Slate Creeks.





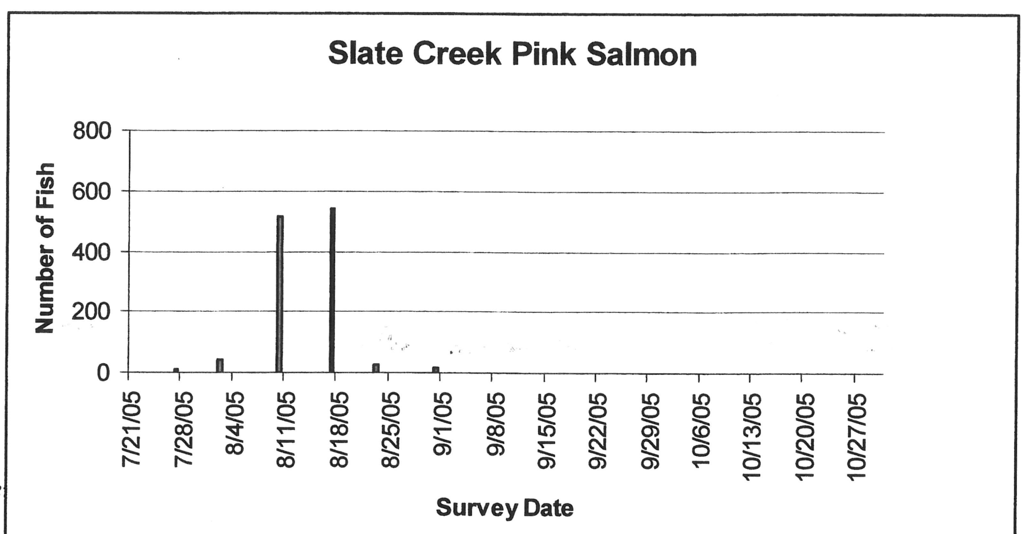
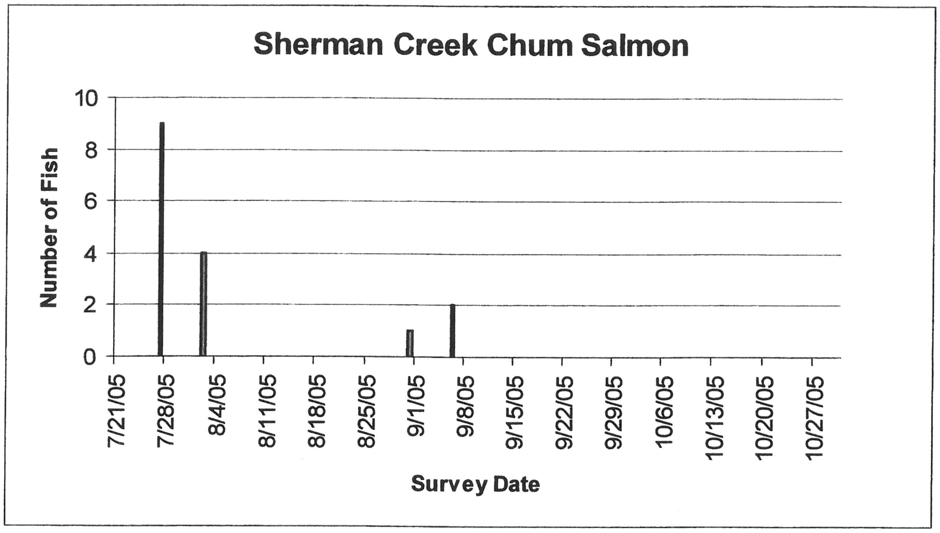
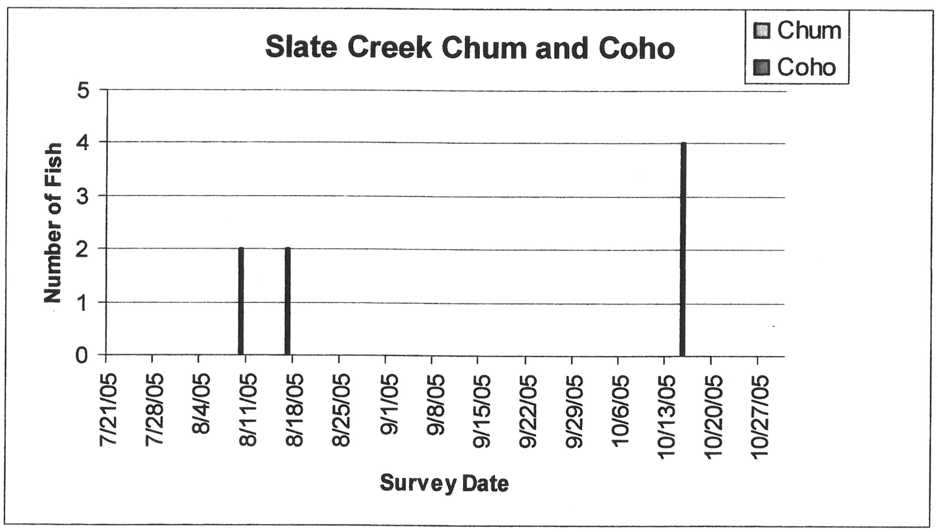


Figure 11: Weekly Counts of Chum and Coho Salmon in Sherman, Johnson and Slate Creeks.





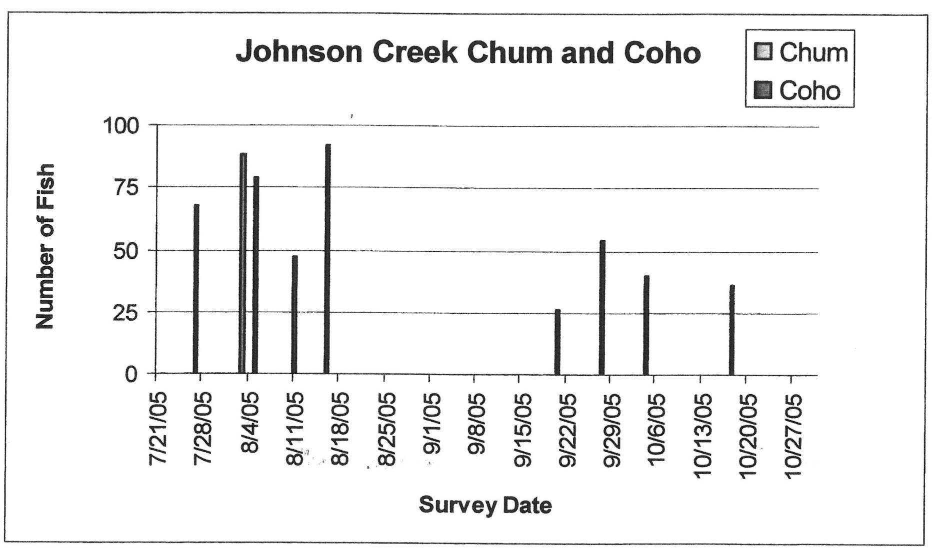
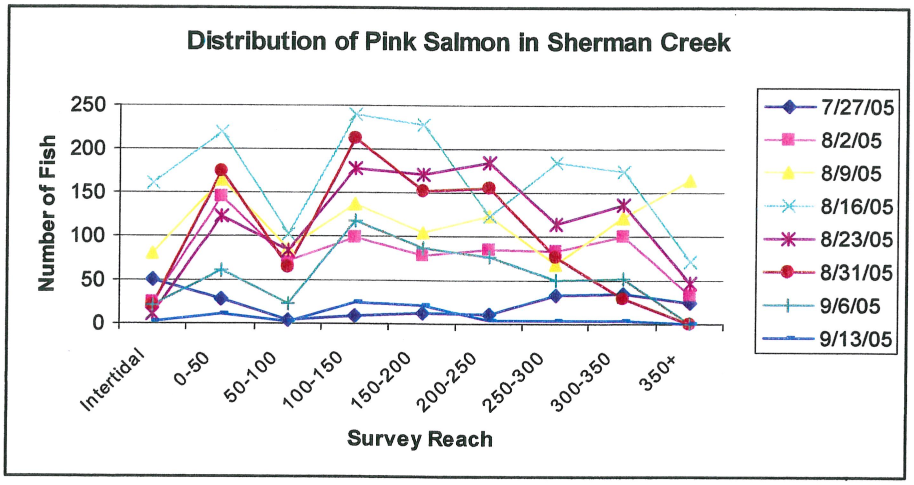
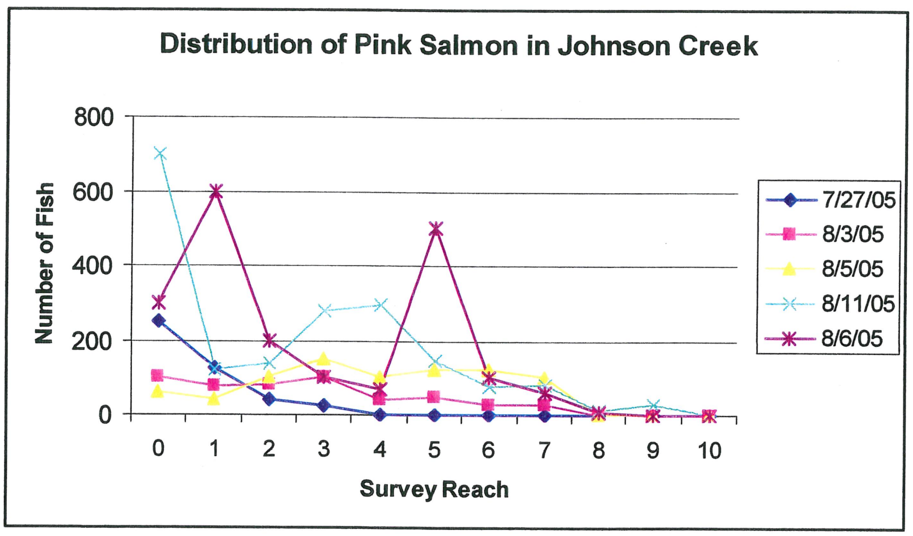
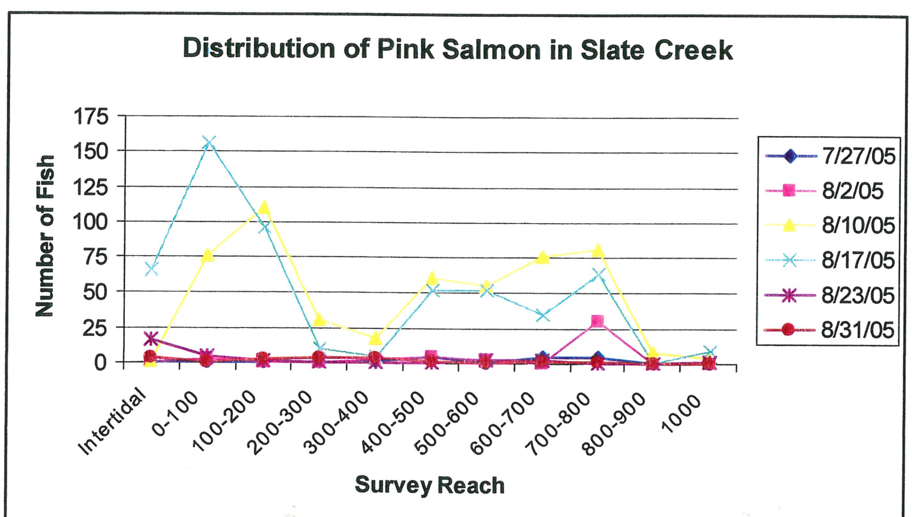


Figure 12: Distribution of Salmon in each creek in 2005.







7.0 Quality of Spawning Substrate

7.1 Sample Collection and Analysis

Samples of spawning gravel were collected from each of two reaches in Sherman Creek on July 10, in Johnson Creek on July 13, and in Slate Creek on July 17, 2005. The two reaches in Sherman Creek lie between 3 and 29m, and between 288 and 315m from the stream mouth as defined by Konopacky (1992). The two reaches in Johnson Creek are located between 320 and 340m, and between 425 and 450m from the stream mouth. The two reaches in Slate Creek are located between 125 and 150m, and between 175 and 200m from the stream mouth. Four samples were collected from each reach using a McNeil-type sampler with a coring diameter of 15cm and a coring depth of 25cm. Individual sample sites were randomly chosen from all potential spawning areas that were suitable for sampling, namely, substrate size less than 15cm and water depth less than 30cm.

Figure 13: Measuring the volume of gravel at each size class involves on-site sieving and settling of fine material.

Collected substrate was wet-sieved on site through the following sieve sizes given in mm: 101.6, 50.8, 25.4, 12.7, 6.35, 1.68, 0.42, and 0.15, which were used by Konopacky (1992). The contents of each sieve were allowed to drain, then were measured by volume displacement to the nearest 5ml for the 101.6 to 0.42mm sieve sizes and to the nearest 1ml for the 0.15mm sieve. Fine material that passed through the smallest sieve was placed in an Imhoff cone to settle out; this volume was read directly from the cone measured marks on the cone.

Due to the presence of interstitial and surface water in each sample, the volumetric measurements were converted to dry weights using correction factors determined by Shirazi et al (1981) assuming a gravel density of 2.6g/cm^3. The geometric mean particle size and sorting coefficient (the distribution of grain sizes present) were calculated for each sample using methods from Lotspeich & Everest (1981). The geometric mean particle size (d_g) is an index of the textural composition. The grain size at the midpoint of each size class is raised to a power equal to the decimal fraction of its volume. The products of each size class are then multiplied together to obtain d_g:

$$d_g = (d_1^{v1} \times d_2^{v2} \ldots\ldots\ldots\ldots\ldots \times d_n^{v_n})$$

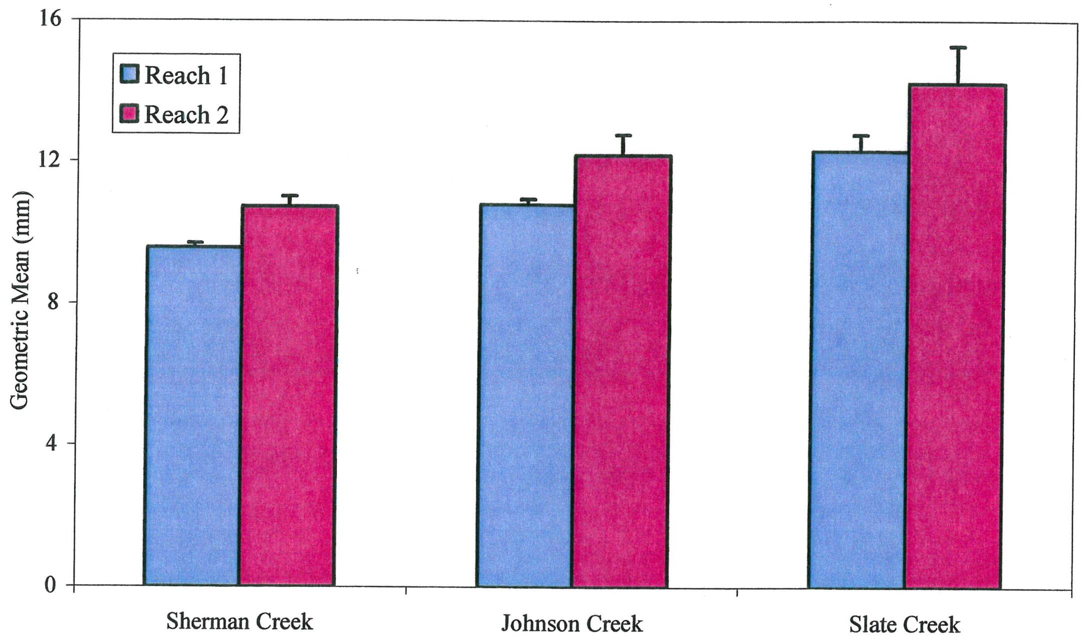
where dg = geometric mean particle size

d = midpoint diameter of particles retained by a given sieve

v = decimal fraction by volume of particles retained by a given sieve

The sorting coefficient (S_o) is an index of the size distribution of sediment particles in a sample and provides a useful indicator of the permeability of gravel for salmonid spawning. The grain size at the 75th percentile of total sample volume is divided by that at the 25th percentile. The square root of the result provides the sorting coefficient. A gravel consisting of only one grain size has a S_o of 1. A S_o greater than 1 represents gravel made up of several grain sizes, the smaller grains filling up pores between larger ones. S_o is therefore inversely proportional to permeability (Lotspeich & Everest, 1981).

Figure 14. A comparison of Spawning gravel geometric mean particle size between sampled reaches and creeks.



The Fredle index (F_i), or stream quality index, is a ratio of geometric mean particle size and sorting coefficient and provides a measure of the quality of spawning gravel for salmonid reproduction (Lotspeich and Everest, 1981). As the magnitude of the Fredle index increases, both pore size and permeability increase.

$$F_i = d_g/S_o$$

7.2 Spawning Gravel Composition

The volumetric measurements of gravel sizes retained by sieves are presented in Appendix 4. The geometric mean particle sizes (d_g), grain size percentiles (75^{th} and 25^{th}), sorting coefficients (S_o), Fredle Indexes (F_i), and Embryo Survival Prediction (%) are presented in Table 13. Embryo survival predictions and grain size percentiles are obtained graphically.

Sediment texture affects salmonid embryo survival by influencing the pore size and permeability of the gravel. These properties regulate oxygen transport to incubating embryos and control the movement of alevins within the gravel (Lotspeich & Everest, 1981). An excess of fine sediments in spawning gravel is a direct cause of embryo and alevin mortality (Shirazi et al, 1981). The higher the numerical value of the geometric mean the higher is the survival percentage of salmonid embryos.

Based on published relationships between these indices and salmon embryo survival rates (Chapman, 1988; Lotspeich and Everest, 1981), geometric mean particle size and Fredle indexes for gravel samples collected in July 2005 predict embryo survival to range from 45 to 78% for both reaches of Johnson and Slate Creek. Sherman Creek embryo survival prediction ranges from 58% in the lower reach down to 14% in the upper reach.

Table 13. Calculated Indices for Spawning Gravel samples collected from Sherman, Johnson, and Slate Creeks in July 2005

	Sample	Geometric Mean Dg	Grain size percentile (75th and 25th) d75	d25	Sorting Coefficient So	Fredle Index (f =Dg/So)	Embryo Survival Prediction (%)
	Sherman Creek						
Reach 1	1	9.94	8	0.87	3.03	3.28	54.0
	2	9.57	5.40	0.72	2.74	3.49	57.0
	3	9.47	3.95	0.69	2.39	3.96	64.0
	4	9.30	3.95	0.61	2.56	3.64	60.0
	Mean	**9.57**	**5.33**	**0.72**	**2.68**	**3.59**	**58.8**
	Standard Deviation	0.27	1.91	0.11	0.27	0.29	4.3
	95% Confidence Interval	0.27	1.87	0.11	0.27	0.28	4.2
Reach 2	1	1.80	19.50	0.96	4.51	0.40	8.0
	2	2.79	5.40	0.75	2.68	1.04	10.0
	3	3.63	14.00	2.80	2.24	1.62	22.0
	4	3.37	11.50	2.20	2.29	1.47	19.0
	Mean	**2.90**	**12.60**	**1.68**	**2.93**	**1.13**	**14.8**
	Standard Deviation	0.81	5.85	0.98	1.07	0.55	6.8
	95% Confidence Interval	0.79	5.73	0.96	1.05	0.54	6.7
	Johnson Creek						
Reach 1	1	10.76	10.00	0.68	3.83	2.81	47.0
	2	11.04	12.80	0.78	4.05	2.73	46.0
	3	11.03	11.50	0.78	3.84	2.87	50.0
	4	10.38	9.00	0.45	4.47	2.32	39.0
	Mean	**10.80**	**10.83**	**0.67**	**4.05**	**2.68**	**45.5**
	Standard Deviation	0.31	1.67	0.16	0.30	0.25	4.7
	95% Confidence Interval	0.31	1.64	0.15	0.29	0.24	4.6
Reach 2	1	11.80	19.20	1.10	4.18	2.82	47.5
	2	13.64	27.00	7.55	1.89	7.21	87.0
	3	12.51	20.00	1.60	3.54	3.54	58.0
	4	10.85	11.00	0.80	3.72	2.92	51.0
	Mean	**12.20**	**19.30**	**2.76**	**3.33**	**4.12**	**60.9**
	Standard Deviation	1.17	6.55	3.21	1.00	2.08	18.0
	95% Confidence Interval	1.15	6.42	3.15	0.98	2.04	17.6
	Slate Creek						
Reach 1	1	11.60	21.40	1.80	3.45	3.37	55.0
	2	11.63	20.00	1.25	4.00	2.91	51.3
	3	13.60	24.50	7.90	1.76	7.72	89.0
	4	12.42	20.80	2.60	2.83	4.39	67.0
	Mean	**12.31**	**21.68**	**3.39**	**3.01**	**4.60**	**65.6**
	Standard Deviation	0.94	1.97	3.06	0.96	2.17	17.0
	95% Confidence Interval	0.92	1.93	3.00	0.94	2.13	16.7
Reach 2	1	13.12	29.50	3.40	2.95	4.46	68.0
	2	13.14	29.00	4.25	2.61	5.03	72.0
	3	13.20	26.00	5.80	2.12	6.23	80.0
	4	17.47	37.00	9.70	1.95	8.95	95.0
	Mean	**14.23**	**30.38**	**5.79**	**2.41**	**6.17**	**78.8**
	Standard Deviation	2.16	4.68	2.79	0.46	2.00	11.9
	95% Confidence Interval	2.12	4.59	2.74	0.45	1.96	11.7

**d75, d25, and Predicted Embro Survival percentages obtained graphically

8.0 Aquatic Vegetation

A visual survey of instream vegetation was carried out in the lower and middle stream reaches in July and August 2005. These reaches are downstream of outfall 001 (Sherman Creek), the proposed outfall 002 (Slate Creek) and the process mill (Johnson Creek). In Sherman Creek, aquatic vegetation was negligible with only larger, more stable substrate exhibiting a thin algal covering (Figure 14). Periodic high flows in the stream are likely to disturb the substrate and restrict aquatic plant growth.

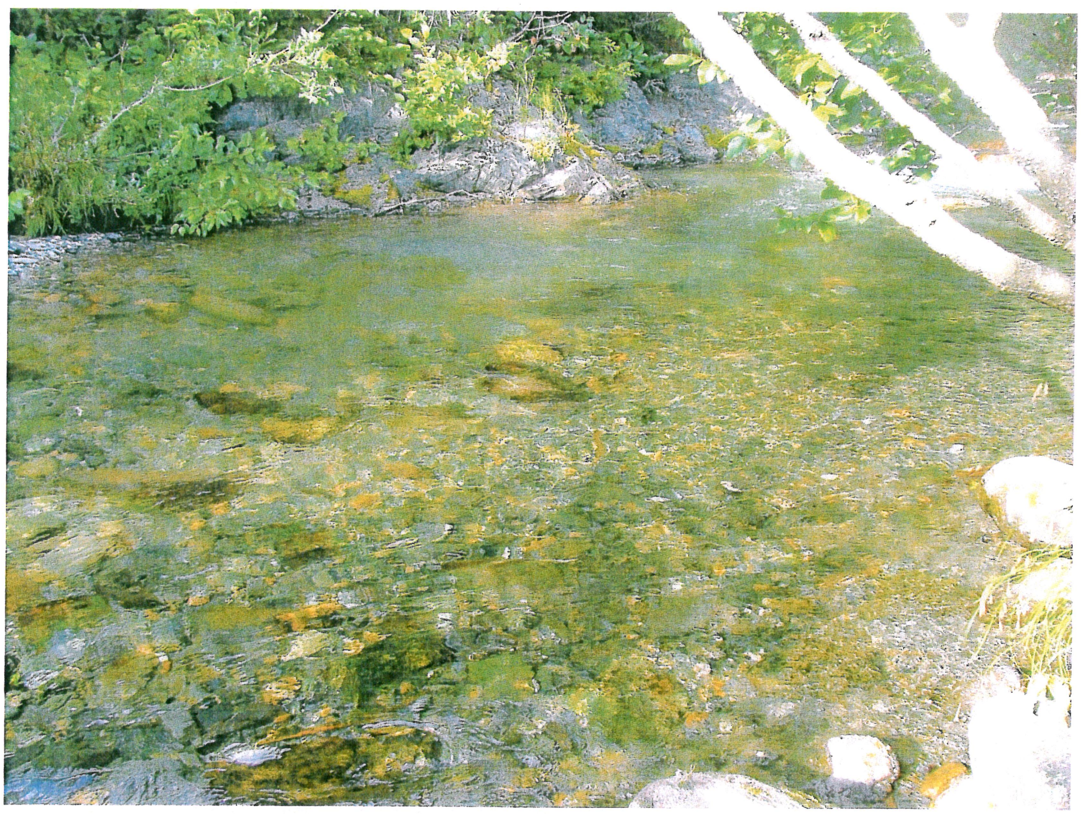


Figure 14: Lower Sherman Creek; little aquatic vegetation

Johnson and Slate Creeks showed very little aquatic vegetation on the substrate (Figures 15 and 16). Some mosses and ferns are present in the splash zone in Slate Creek particularly near waterfalls. The lakes in this system likely help maintain stable flows and lessen the magnitude of high flow events that could remove these riparian plants. Aquatic vegetation of the lakes themselves is presented in a separate report.

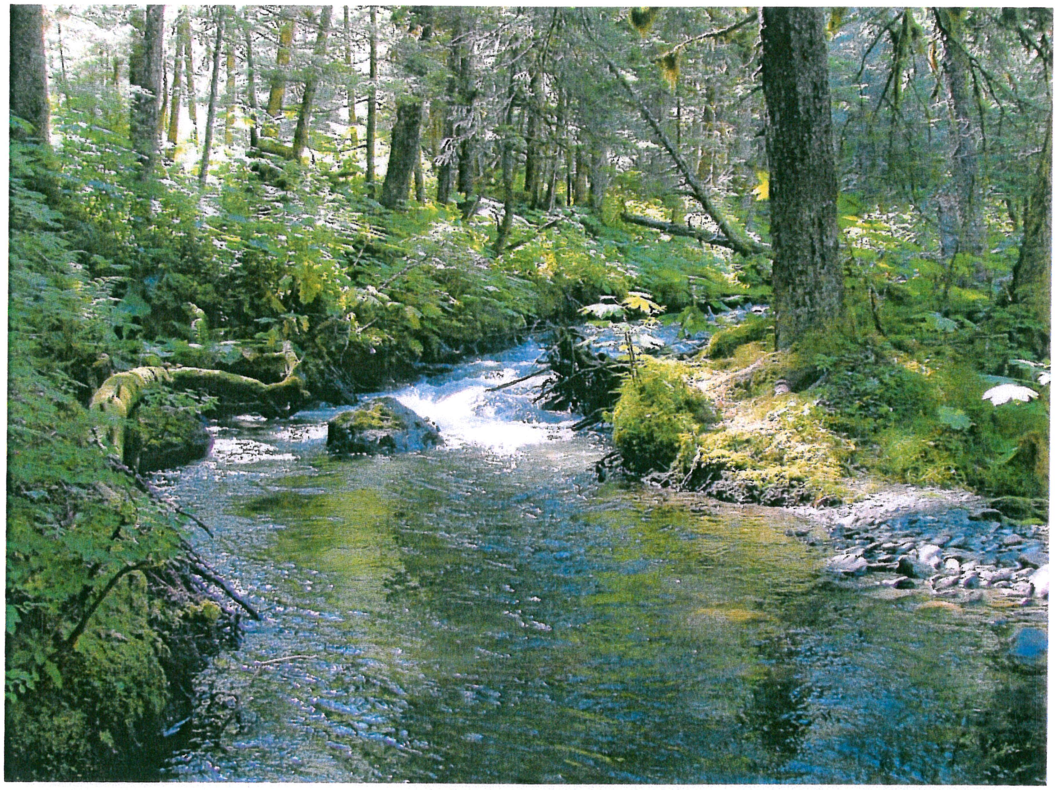


Figure 15: Lower Johnson Creek; negligible vegetation in stream

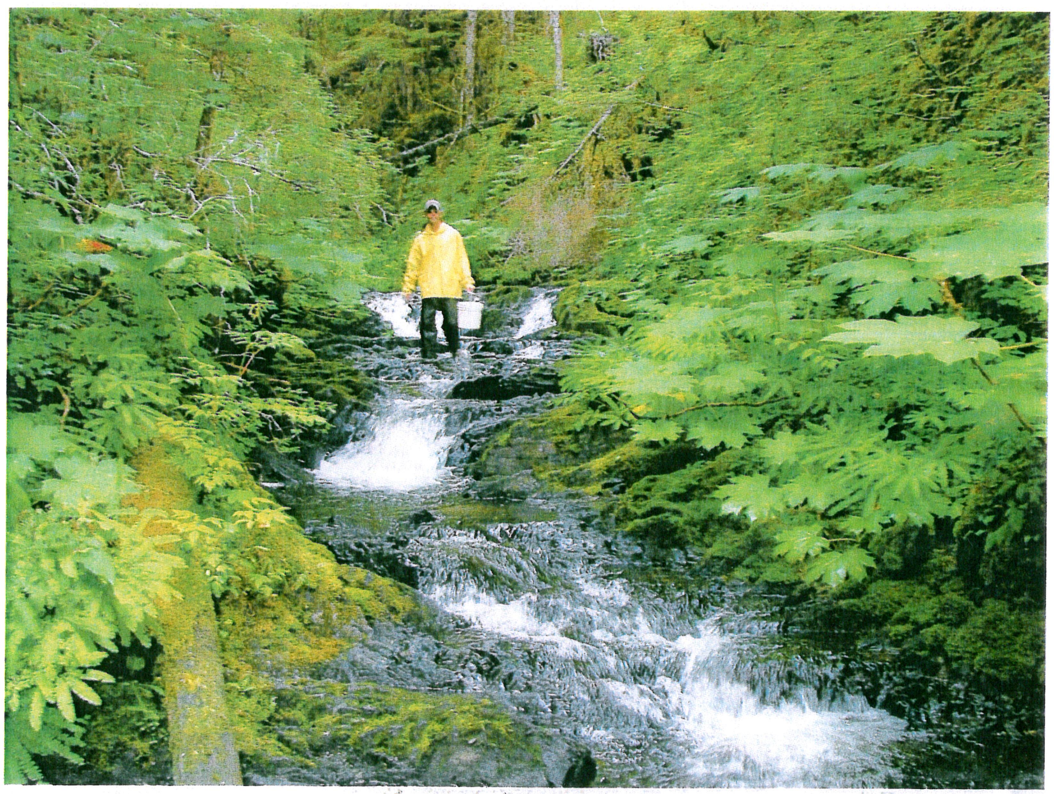


Figure 16: Middle Slate Creek (700m downstream from Lower Slate Lake)

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List of Appendices

Appendix 1a: Laboratory report on sediment grain size, metal analyses and physical parameters.

Appendix 1b: Laboratory report of short-term toxicity of whole sediment to *Chironomus tentans*.

Appendix 1c: Laboratory report of short-term toxicity of whole sediment to *Hyalella azteca*.

Appendix 2a: Habitat units and resident fish counts for 2005. Habitat types correspond to a horizontal distance along the stream measured in meters from the stream mouth. Counts of fish are shown for both snorkel and electrofishing surveys.

Appendix 2b: Area of each habitat type by stratum.

Appendix 2c: Length, weight and condition factor of resident fish.

Appendix 3: Weekly counts of salmon in Sherman, Johnson and Slate Creeks.

Appendix 4: Size Distribution of Spawning Gravel